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## QUESTIONS IN REGARD TO THE DIPHTHERIA BACILLUS.

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There is no longer any question in regard to the identification of the diphtheria bacillus. That has been settled beyond dispute. There is much to be learned, however, in regard to its varieties, and their behavior under different conditions in and out of the body, and in association with other micro-organisms, as well as when present alone. For the purpose of such study there are two methods, each of which should supplement the other. These minute forms of life become known to us, not only as they appear under the microscope, but also by the behavior of the diseases which they produce. Thus the questions that force themselves on our attention during an epidemic become a guide for further microscopical study, and it is for the most part questions encountered in this way that it is now proposed to mention.

A very important question is that of the life history of the bacillus in the human throat under various forms of treatment, and without treatment. Since it has become customary with health boards to make the duration of quarantine depend upon the results of microscopical examination of cultures of bacilli from the throats of those having the disease and those exposed, there has been a tendency to concentrate attention upon this mode of propagation from individual to individual. There is no doubt that so long as the bacillus is present, even in the absence of all clinical symptoms of diphtheria, there is danger of conveying the disease, and measures of throat disinfection, and immunization of the person, and quarantine, should be persisted in until it is certain that all danger is past. Attention to detail is important in this connection. Disinfectant

solutions for use in the throat require to be rightly applied at sufficiently frequent intervals, and in such manner as to reach behind the palate and into the back of the nostrils, or they will fail no matter how well adapted by their chemical and physical properties to destroy the bacillus. In like manner the antitoxin, if used for purposes of immunization, requires to be of proper strength, and given early. It is safe to say that without the use of such measures, and quarantine of proper duration, diphtheria will inevitably spread. But even when these precautions have been employed thoroughly they may fail to eradicate the disease from particular localities. In other words the growth of the bacillus in the throat, whether in typical or atypical forms, does not account for the manner in which diphtheria sometimes remains endemic in a particular household or neighborhood in spite of quarantine and throat disinfection. A very notable instance of this sort was reported at the Montreal meeting of the British Medical Association last year, and again at the American Public Health Association at Ottawa this year. In this case diphtheria has continued to recur in a state school in Minnesota at frequent intervals for ten years in spite of the most elaborate precautions. In the British Medical Journal for April 16th, 1898, at page 1009, it is stated that an atypical variety of the diphtheria bacillus, supposed to be the cause of the trouble in this school, was found to be confined strictly to inmates of the institution, with one exception in 2400 examinations. In other words there was no endemic prevalence of anything of the sort in the town adjacent, or anywhere else in the state, so far as was known, except in this particular school. Presumably antitoxin, throat disinfection, and quarantine, were all employed with thoroughness commensurate with the interest that such a state of affairs, and its wide publication, would arouse, and yet the disease continued to recur.

It would seem evident in such a case that there must be some other method of propagation of the bacillus than in human throats, and that the culture medium, whatever it may be, must be located somewhere on the premises, harboring and

perpetuating the infection so that when destroyed within the body of every inmate, reinfection from without becomes possible again. The growth of the bacillus in media external to the body might very well originate atypical forms. But be this as it may, the writer as health officer and practising physician, has repeatedly been brought face to face with this very question as to the life of the diphtheria bacillus outside the body. As a rule when the disease has given evidence of a tendency to recur in a particular house or neighborhood it has been possible to find somewhere about the premises an accumulation of material obviously adapted to serve as a culture medium for this particular bacillus, and so situated that effluvia from it would surely gain access to those very persons who contracted the disease.

In any such case it is, as a rule, difficult to secure pure cultures of any particular bacillus that may be in question. The varieties present are more numerous than in the cultures from the throat so that the one wanted is lost in the crowd, and there may be admixture of much extraneous matter, if direct inoculation of the culture medium is attempted, so that it is difficult to get conclusive evidence. Thus far the best evidence attainable has been the immediate and complete disappearance of the disease, when the proper source of the trouble has been identified, and effectual measures for its removal by disinfection, or otherwise, have been adopted.

Still it is possible that definite information in regard to the life of the bacillus outside the body may be had experimentally. It should be determined for what length of time the bacillus remains alive not only in a single culture, but also in a succession of cultures, transferred from one to another. This may be done with the various media ordinarily employed for such purposes, or with saliva, or pus, or mucus, or other secretions from the body, under varying conditions of temperature and moisture. Thus the development of atypical forms and changes in the virulence of the bacillus due to its mode of life outside the body may be detected by such a succession of cultures starting from a single one.

This is the laboratory side of the question, as yet unworked, except in desultory and fragmentary fashion. Leading up to it from the side of the practical work of the health board, is the identification of such culture material, and its proper disinfection, or destruction. In the experience of the writer a drain pipe that is rarely if ever flushed completely, and that is crusted over on the inside with partly dried filth is specially apt to form a medium for the retention and growth of successive crops of the diphtheria bacillus. Inoculation may occur in various ways, a little expectoration, rinsing the mouth at the kitchen sink, for example, may start the process. The bacilli implanted in an underground drain, or other receptacle that is constantly nearly dry, and never completely flushed, find these conditions very suitable for their growth. The temperature and moisture, and fresh accessions of organic matter from day to day are well adapted to bring about a series of cultures resembling substantially those from tube to tube suggested in the last paragraph. In such a case disinfectant solutions may run along the bottom of the drain leaving the top and sides untouched. Indeed in the case of a very large drain of this sort the writer found it necessary to generate chlorine in order to disinfect it completely. During continuance of infection there is constant liability of its diffusion by the partly dried material becoming detached and carried by the vapors arising from fermentation, or by access of air currents. An instance of this sort that came under the observation of the writer was in connection with a dry closet system, so-called, in a school building. The vaults containing the partly dried excretions were in the cellar, and were cleaned only once or twice a year and never disinfected. Under these conditions an outbreak of diphtheria among the children appears to have been brought about by this material in the cellar becoming infected perhaps by particles of partly dried mucus containing the bacillus being carried down through the ventilating flues which were built so as to pass through these vaults. Infection once accomplished propagation of the bacillus on a large scale would ensue on the plan of plate cultures, there being accessions of fresh material

suitable for the purpose daily. This being the case it would need only some failure of the ventilating apparatus to allow the vapors arising to find their way into the rooms most distant from the main ventilating shaft and it was in these rooms precisely that the disease occurred and spread. An effort was made in this case to secure cultures, but the difficulty was that the bacterial flora was too abundant, and the particular bacillus sought was lost in the crowd, as in other experiments of the kind with drain pipes and receptacles having the peculiarities indicated.

A very important point in connection with such prevalence of diphtheria as has just been indicated, is the occurrence simultaneously of much ordinary sore throat so-called, in which the usual form of the diphtheria bacillus appears to be wanting. It has occurred to the writer that some atypical variety of the bacillus, of greatly attenuated virulence, through an succession of cultures outside the body, may be responsible for this form of throat trouble, often spoken of at such times as sympathetic sore throat. I would regard this form of the disease, in connection with an outbreak of diphtheria, as clear evidence that it was becoming endemic in the locality; in other words that cultures outside the body were in progress somewhere in the vicinity.

Mixed infection, or the association of diphtheria bacilli with streptococci and other micro-organisms, is of great interest because of the increased danger to life, and because it may serve to explain at times the failure of the antitoxin which does not protect against other toxins than that of diphtheria. But these are points of interest to the practicing physician rather than the microscopist.

The fact that diphtheria, like many other diseases, spreads in waves over extensive portions of the earth's surface, increasing very largely for a year or two, and then subsiding for a series of years, is usually referred to meteorological conditions modifying the virulence of the bacillus itself, or modifying the conditions on which its virulence depends. It may, however, be a question for study by the methods of modern microscopy.

It is possible that the products of bacterial activity may inhibit the growth of these organisms, in and out of the body, on a scale large enough to be evident at a glance in the statistics showing their epidemic prevalence. In other words even when practically left to themselves, as is the rule in many parts of the world, they do not increase indefinitely but exhaust the material susceptible to their attack, and perhaps in a measure originate their own antitoxines. In either case it is a question to be determined by the culture methods of the bacteriologist and microscopist, identifying atypical and modified forms of the bacillus, and their relation to the severity of the disease in particular cases, and its epidemic prevalence in general.

Another exceedingly interesting series of questions is as to why the bacillus attacks children in preference to adults, and certain tissues and parts of the body in preference to others. Considerable light has been thrown upon these very difficult and obscure phases of the subject by modern methods of study of embryology and comparative anatomy, bringing out what may be termed the developmental relations involved. This is the special field of the histologist and microscopist, and it is likely to be exceedingly fruitful in the near future. Comparative pathology is the outcome; this is just beginning to be recognized as a part of the medical curriculum and is likely to answer many questions along the lines just indicated in this paragraph.